Laser Use Outdoors

DOE Advanced LSO Workshop

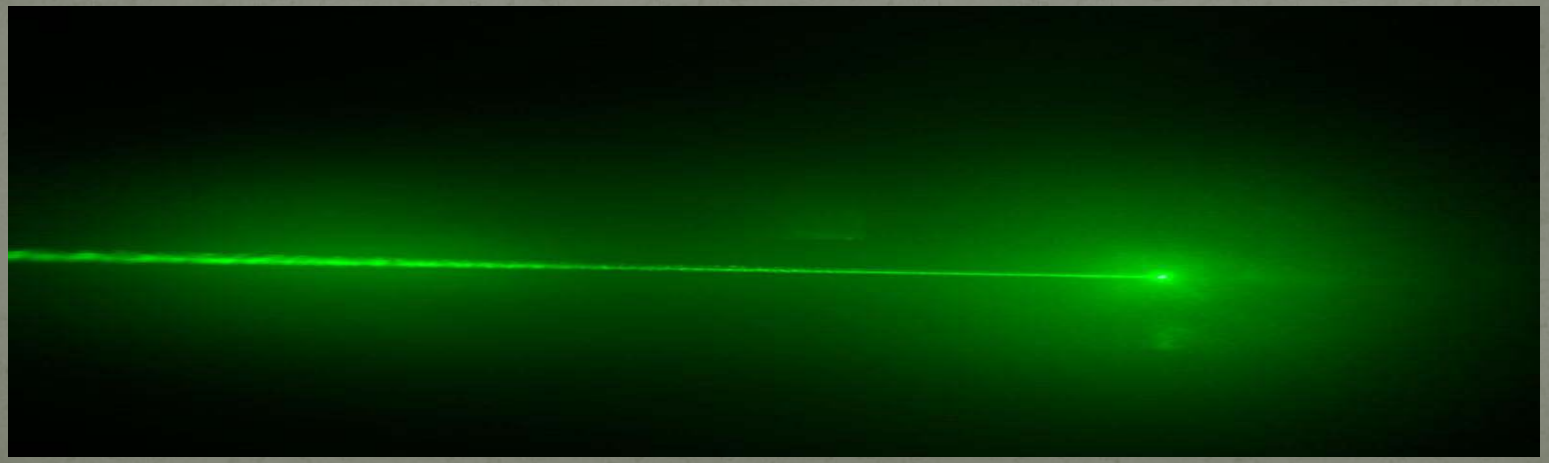
MIT-Cambridge, MA
August 2011

Donald L. Haes, Jr., CHP

Certified Laser Safety Officer

Scenarios Leading to Outdoor Use

- Aircraft
  - Air through air
  - Air to ground/water
- Laser Light Shows
  - Ground through air
- Research

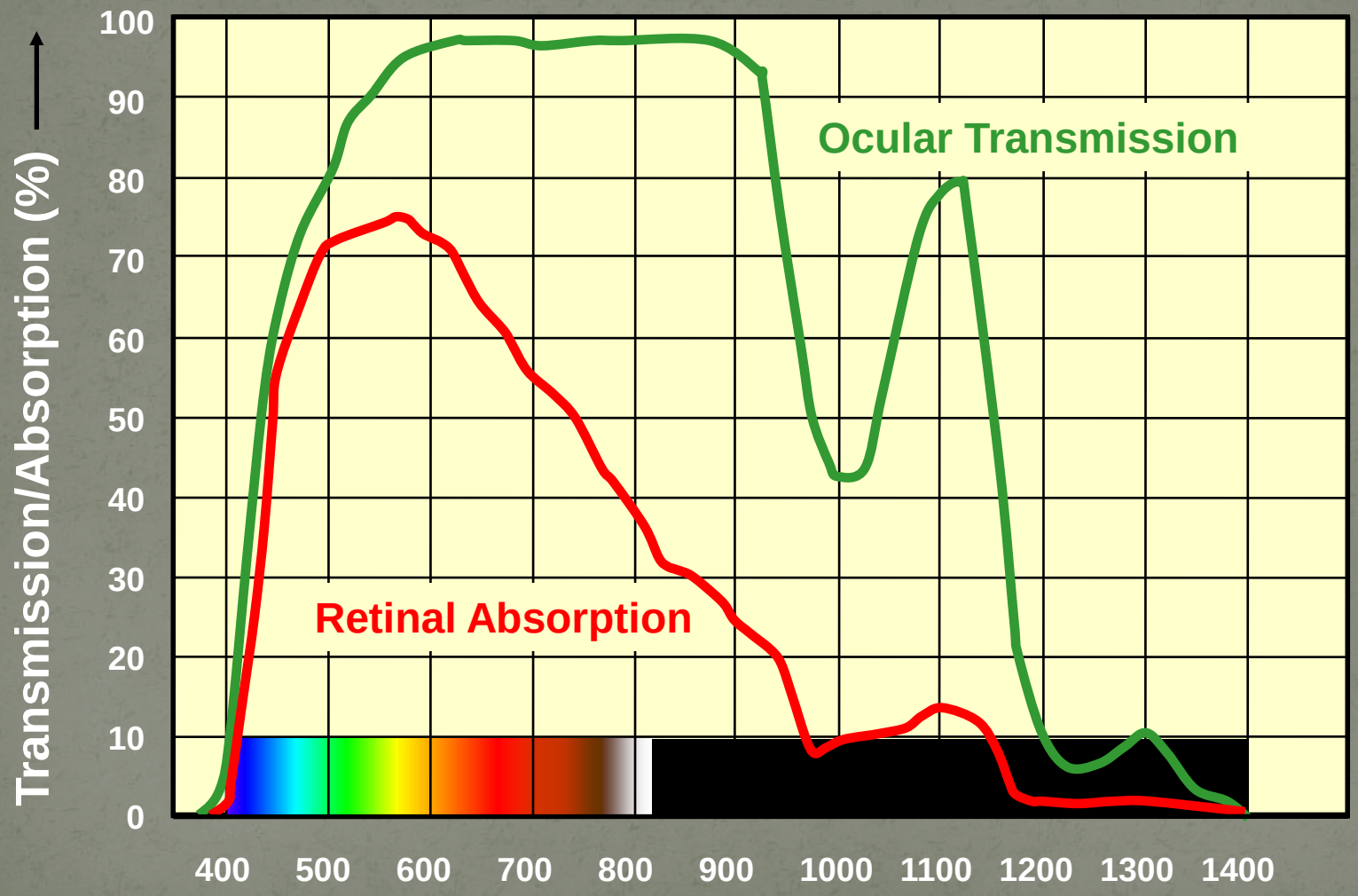


As LSO… you know your duties*

- Classification
- Hazard Evaluation
- Control Measures
- Procedure Approvals
- Protective Equipment
- Signs and Labels
- Facility and Equipment
- Safety Features Audits
- Training
- Medical Surveillance

* ANSI Z136.1-2007

Ocular Transmission - Retinal Absorption



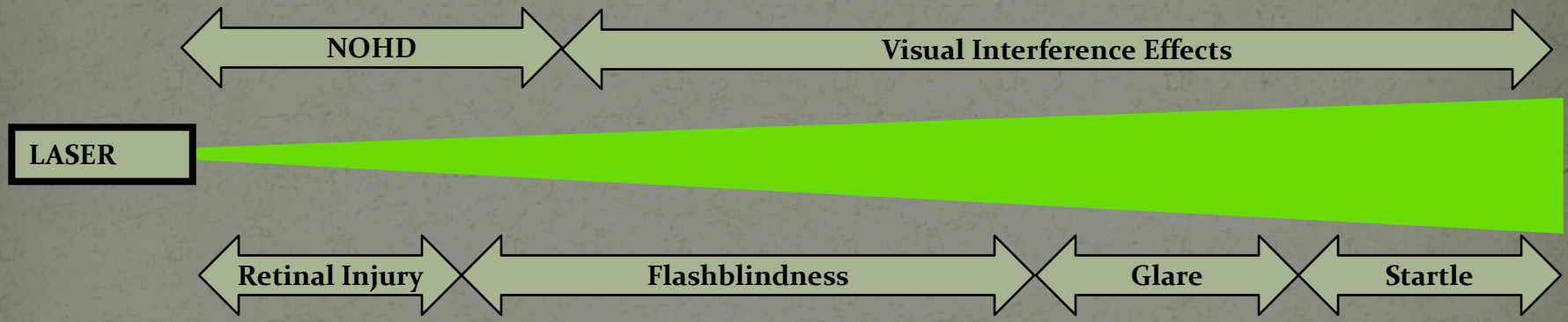
Visual Interference Effects*

- **Dazzle:** To lose clear vision from looking at a bright light.
- **Startle:** In this standard, an involuntary movement or reaction resulting from a sudden or unexpected stimulus, such as a bright light abruptly appearing in one's field of view.
- **Disability glare:** Obscuration of an object in a person's field of vision due to a bright light source located near the same line-of-sight.
- **Flashblindness:** Generally, a temporary visual interference effect that persists after the source of illumination has ceased.

* ANSI Z136.6-2005

Primary Beam Ocular Hazards

Visible beams (400-700nm)



As LSO… you know your duties*

- Classification
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- Safety Procedures/Audits
- Training
- Medical Surveillance

Regulatory compliance?

Outdoor Laser Use

Applicable Regulations & Safety Standards

- ANSI Z136.1 (2007) – *Safe Use of Lasers.*
- ANSI Z136.6 (2005†) – *Safe Use Of Lasers Outdoors.*
- *FDA 21 CFR 1040.10 ‡ – Laser Products.*
- *OSHA 29 CFR 1926.54 – Nonionizing Radiation.*
- *FAA Order 7400.2H & AC70-1 – Outdoor Laser Operations.*
- CJCCSI (Chairman of The Joint Chiefs of Staff) INSTRUCTION §3225.01 – *(DOD Instruction 3100.11) Illumination of Objects in Space by Lasers.*

† Ballot for Z136.6 Draft Standard by the SSC-6 May 2011.

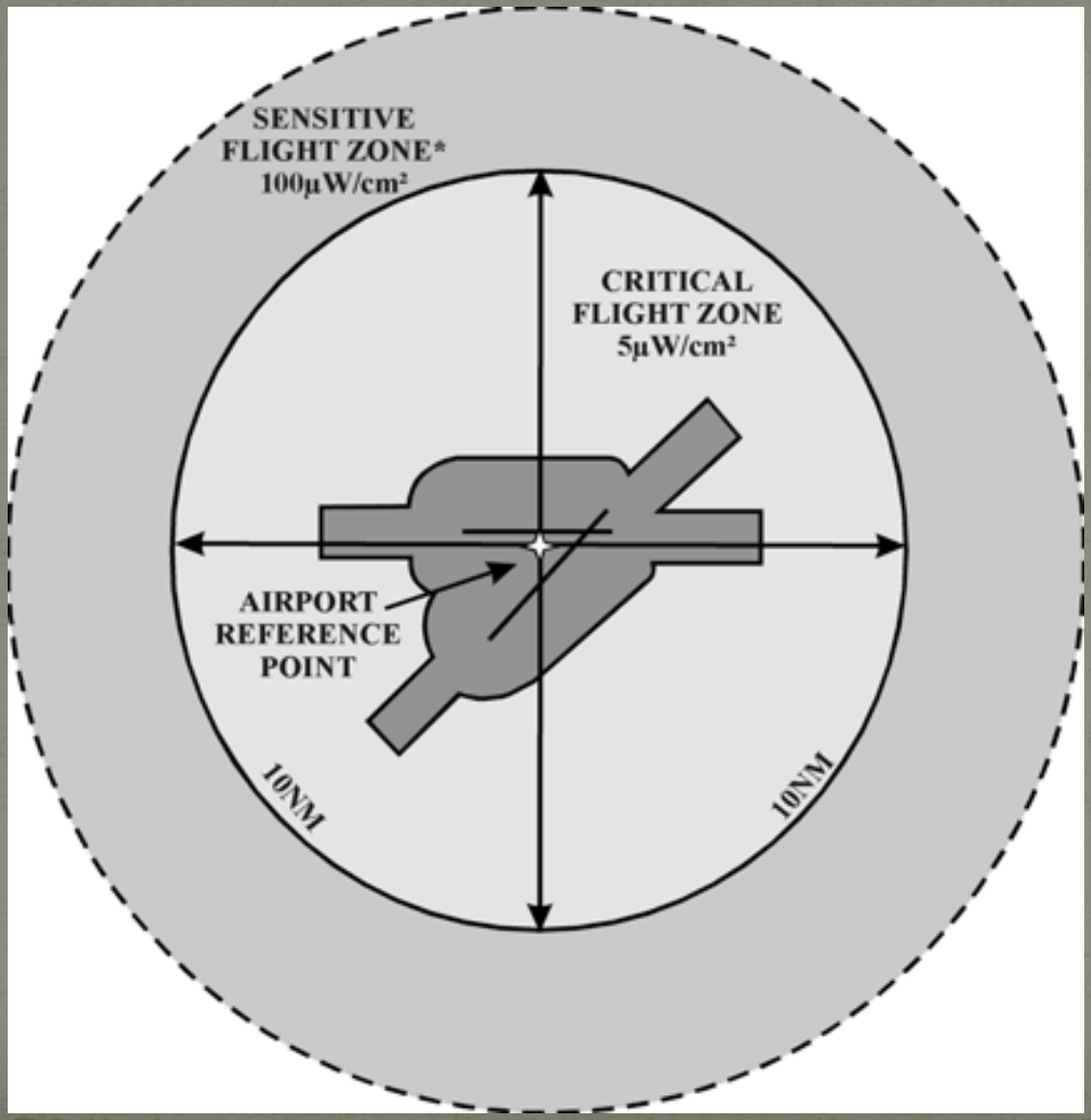
‡ All demonstration lasers in excess of 5 mW used outdoors are required to have a variance from the FDA/CDRH.

Flight Hazard Zones and Visual Interference Levels (VIL)

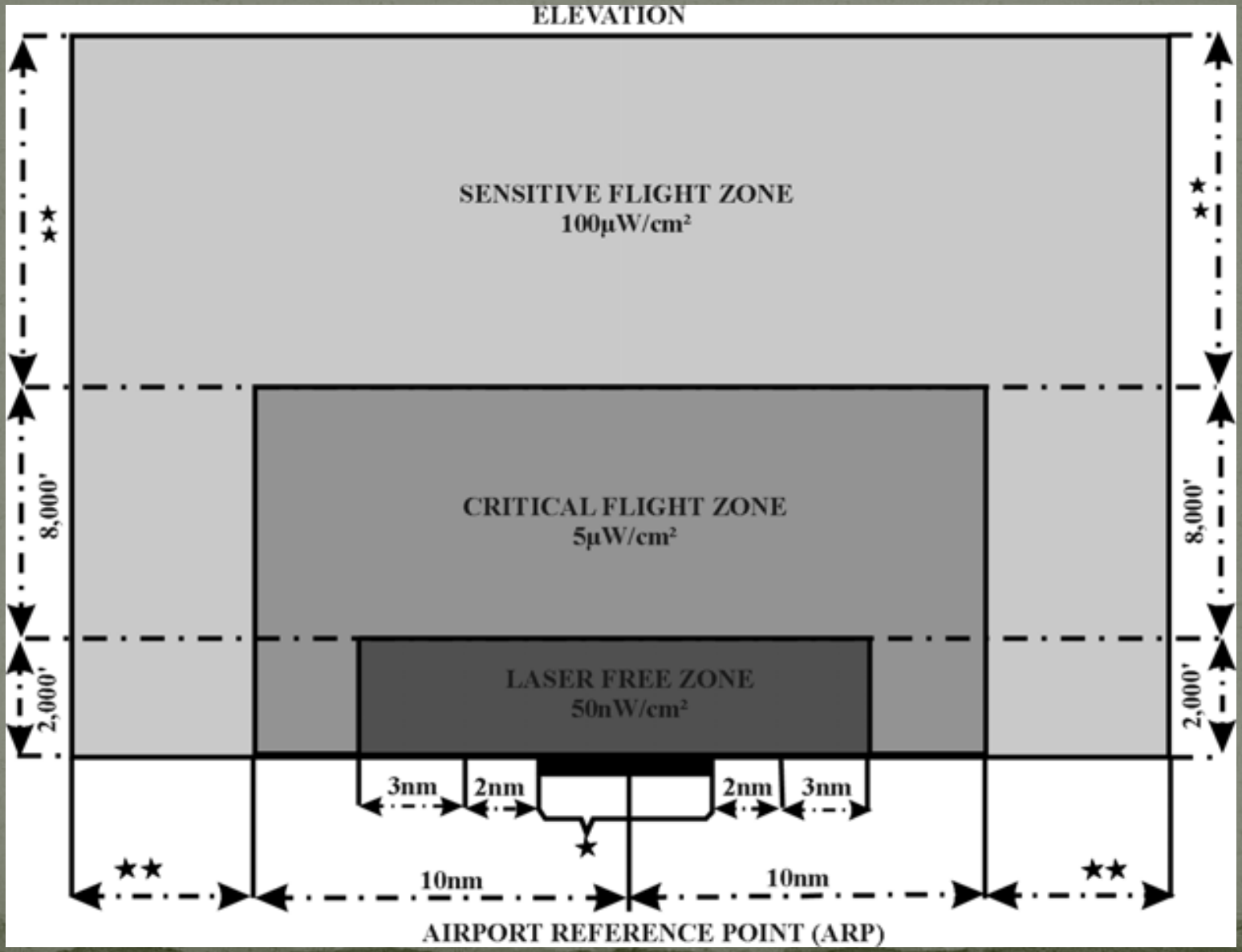
"For the purpose of laser safety, the wavelengths of light that are visible (used for LFZ, CFZ, and SFZ calculations) range from 380 to 780 nanometers (nm)."

Zones	Effective Irradiance
Normal Flight Zone	MPE (2.6 mW/cm² CW visible lasers)
Sensitive Zone	100 μW/cm²
Critical Zone	5 μW/cm²
Laser-Free Zone	50 nW/cm²

Interference Zones around Multiple Runways



Profile of Flight Zones



Laser Safety Clearing House (LCH) Review of DOD Lasers

- The LCH is a mission under the Directed Energy Branch of US Strategic Command / Joint Functional Component Command –Space (USSTRATCOM/JFCC SPACE).
- An entity that develops a laser for the DOD, with the potential to enter airspace, either through the main beam or a reflection (e.g. off a ground target) must work with the LCH to coordinate outdoor laser operations; or request a waiver (**annually**).
- ANSI Z136.6 published 1 mW/cm^2 at a height of 60,000 feet AGL as a determination whether LCH coordination was necessary; **this has not been accepted by LCH**.
- No exclusions based on CLASS!

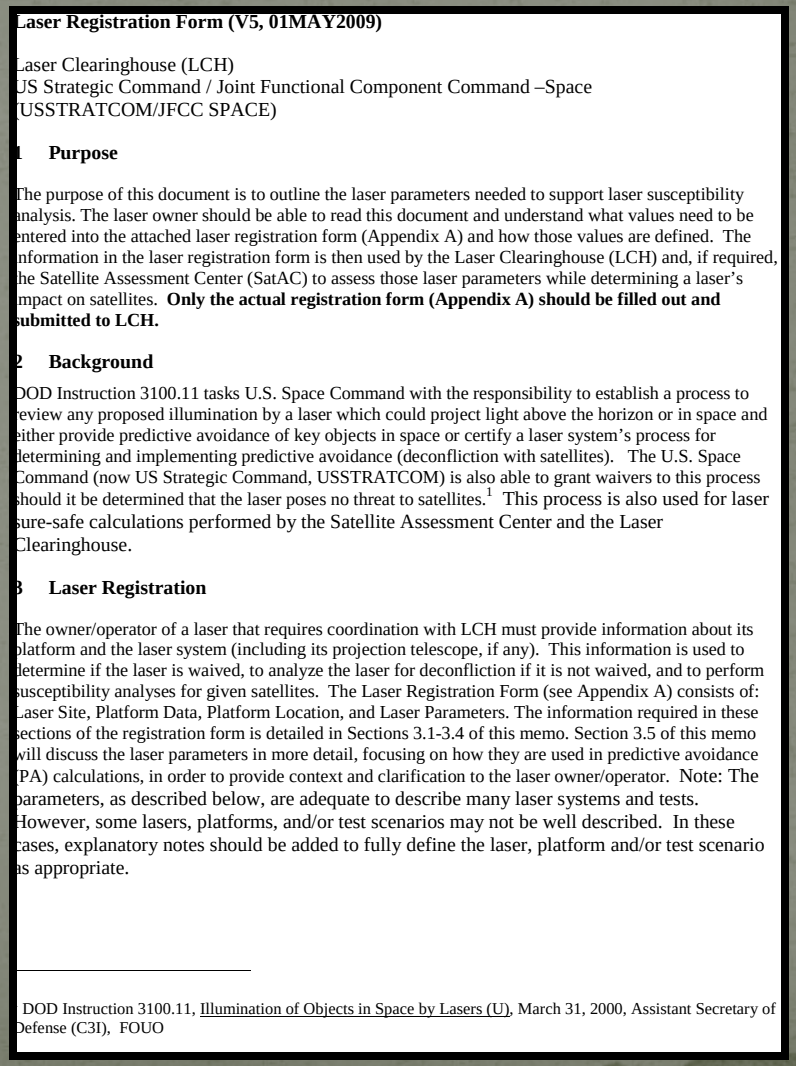
Laser Clearinghouse (LCH)

US Strategic Command / Joint Functional Component Command –Space (USSTRATCOM/JFCC SPACE)

- Send completed "Laser Registration Form (V5, 01 MAY 2009)" to:

JFCC Space J95/LCH, 747 Nebraska Ave, Room B209, VAFB, CA 93437

The information sheet and instructions attached are 18 pages long; **INCOMPLETE** registrations will be refused.



Laser Registration Form (V5, 01MAY2009)

Laser Clearinghouse (LCH)
US Strategic Command / Joint Functional Component Command –Space
(USSTRATCOM/JFCC SPACE)

1 Purpose

The purpose of this document is to outline the laser parameters needed to support laser susceptibility analysis. The laser owner should be able to read this document and understand what values need to be entered into the attached laser registration form (Appendix A) and how those values are defined. The information in the laser registration form is then used by the Laser Clearinghouse (LCH) and, if required, the Satellite Assessment Center (SatAC) to assess those laser parameters while determining a laser's impact on satellites. **Only the actual registration form (Appendix A) should be filled out and submitted to LCH.**

2 Background

DOD Instruction 3100.11 tasks U.S. Space Command with the responsibility to establish a process to review any proposed illumination by a laser which could project light above the horizon or in space and either provide predictive avoidance of key objects in space or certify a laser system's process for determining and implementing predictive avoidance (deconfliction with satellites). The U.S. Space Command (now US Strategic Command, USSTRATCOM) is also able to grant waivers to this process should it be determined that the laser poses no threat to satellites.[1] This process is also used for laser sure-safe calculations performed by the Satellite Assessment Center and the Laser Clearinghouse.

3 Laser Registration

The owner/operator of a laser that requires coordination with LCH must provide information about its platform and the laser system (including its projection telescope, if any). This information is used to determine if the laser is waived, to analyze the laser for deconfliction if it is not waived, and to perform susceptibility analyses for given satellites. The Laser Registration Form (see Appendix A) consists of: Laser Site, Platform Data, Platform Location, and Laser Parameters. The information required in these sections of the registration form is detailed in Sections 3.1-3.4 of this memo. Section 3.5 of this memo will discuss the laser parameters in more detail, focusing on how they are used in predictive avoidance (PA) calculations, in order to provide context and clarification to the laser owner/operator. Note: The parameters, as described below, are adequate to describe many laser systems and tests. However, some lasers, platforms, and/or test scenarios may not be well described. In these cases, explanatory notes should be added to fully define the laser, platform and/or test scenario as appropriate.

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[1] DOD Instruction 3100.11, Illumination of Objects in Space by Lasers (U), March 31, 2000, Assistant Secretary of Defense (C3I), FOUO

H. R. 386

IN THE SENATE OF THE UNITED STATES
MARCH 1, 2011

"Securing Aircraft Cockpits Against Lasers Act of 2011"

PROHIBITION AGAINST AIMING A LASER POINTER AT AN AIRCRAFT

(a) Whoever **knowingly** aims the beam of a laser pointer at an aircraft in the special aircraft jurisdiction of the United States, or **at the flight path** of such an aircraft, shall be fined under this title or imprisoned not more than 5 years, or both.

(b) As used in this section, the term 'laser pointer' means any device designed or used to amplify electromagnetic radiation by stimulated emission that emits a beam **designed to be used by the operator as a pointer or highlighter** to indicate, mark, or identify a specific position, place, item, or object.

Highlighting MY emphasis only

Local State Laser Regulations

- **New Hampshire: Criminal Code; Assault And Related Offenses**
  - Section 631:3-a; Conduct Involving Laser Pointing Devices –
    - A "violation" to illuminate people with "a laser pointing device"; forfeited upon conviction and up to class A misdemeanor (if done to a law enforcement officer).
    - Affirmative defense for "organized meeting or training class", qualified medical , construction, or law enforcement personnel.

- **Massachusetts: 105 CMR 121.000**
  - Registration of "laser facility".
  - Maintain records of receipt, transfer, & disposal of Class 3B or 4.
  - Follow ANSI Z136.1.

- **New York: Part 50 LASERS (§50.1-50.23)**
  - Registration of "laser installations and mobile lasers".
  - "Certificate of competence" required by operators of mobile lasers.

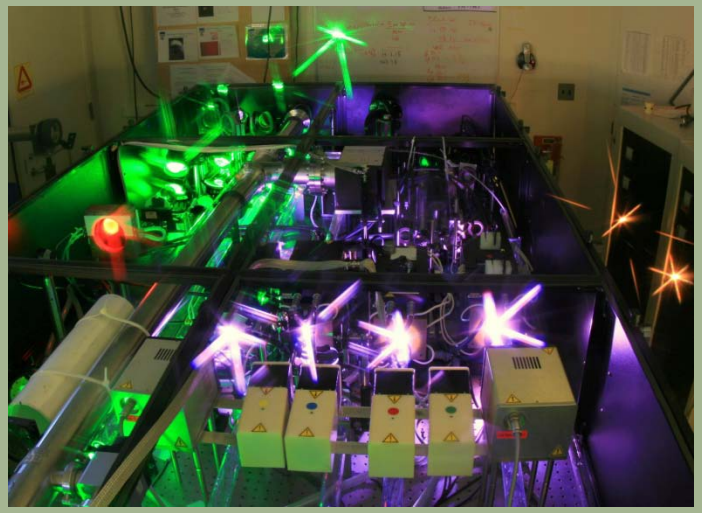
Regulatory Compliance

- ***Should*** be in conformance with ANSI Standard for *Safe Use of Lasers Outdoors* (ANSI Z136.6-2005 or latest revision).
  - FAA Order JO 7400.2H; *Procedures for Handling Airspace Matters:* "voluntary" compliance for other than laser lightshows.

- All laser **LIGHT SHOWS** (> 5 mW) ***MUST*** receive variance from the FDA and "non-objection" letter from FAA.

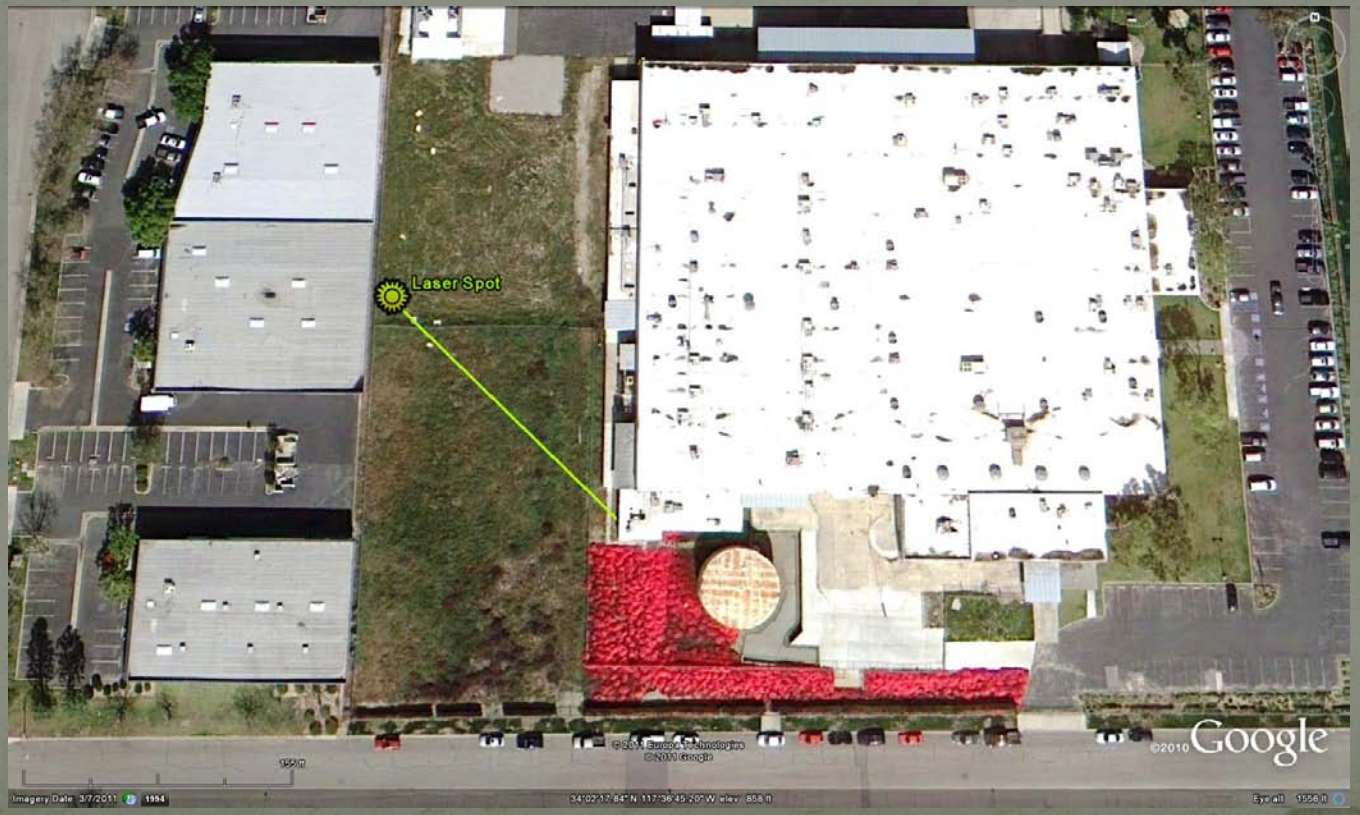
- DOD laser research & testing ***REQUIRED*** to coordinate with Laser Clearing House (LCH) (Ref: CJCCSI 3225.01) for beams above the horizon.

Hey LSO; let's have coff

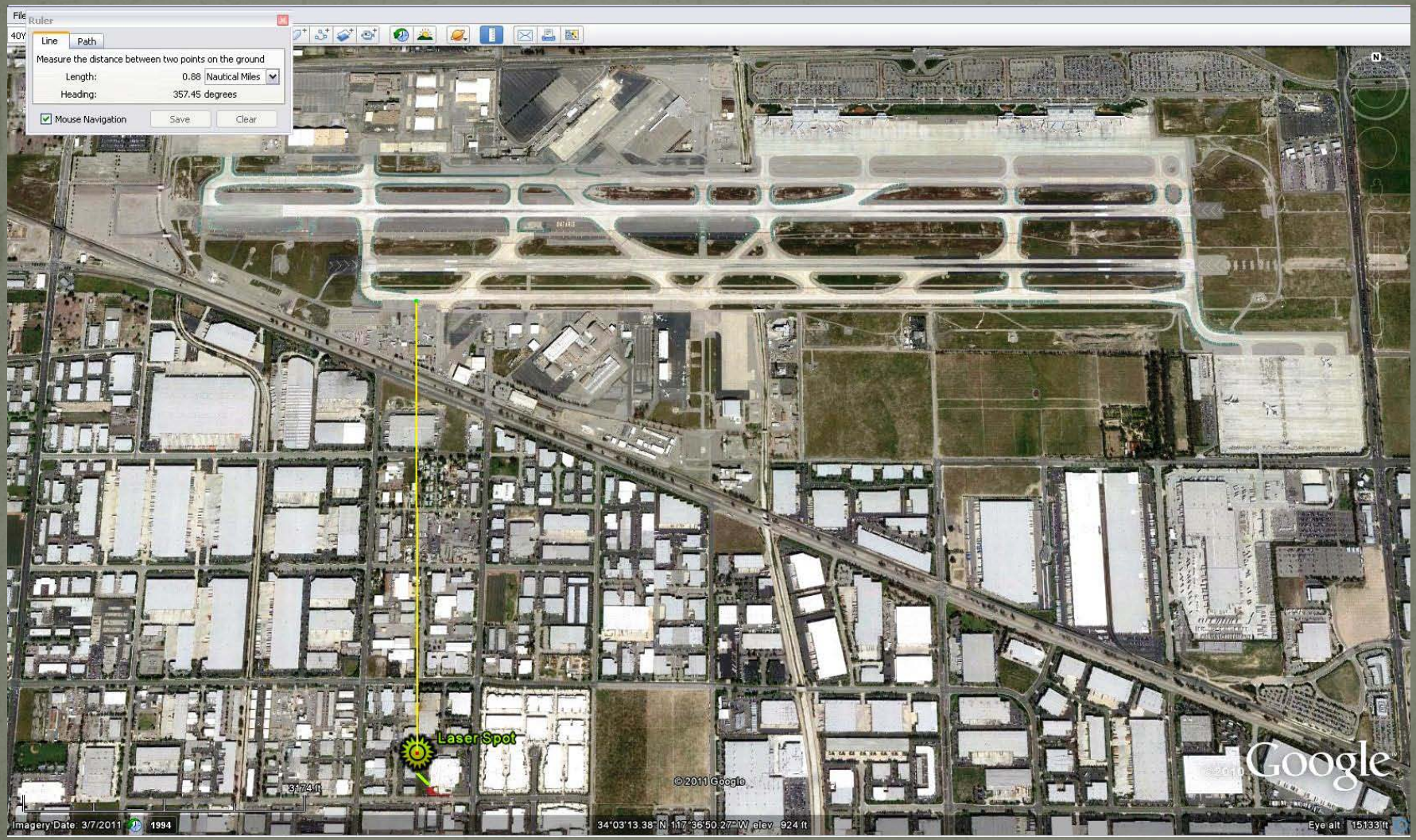


The proposal…

- DPSS Nd:YO_4 @ 532nm
  - ≤ 10 Watt CW
  - Beam Diameter (@ 1/e) ~ 6 mm
  - Divergence (@ 1/e) ~ 0.5 mrad



… the "opportunity for learning"!



Outdoor Laser Safety Methodology

Evaluate Potential Hazards

- Determine the Nominal Hazard Zone (NHZ).
  - May extend from the laser transmitter to the laser backstop including any buffer areas.
    - **Buffer angle:** An angle added to the beam divergence or intended laser projection field in order to ensure a protection zone.
    - **Buffer area:** The projection of the buffer zone around a target, when the ground serves as the beam backstop.
  - Consider any potentially hazardous specular or diffuse reflections.

Outdoor Laser Safety Methodology

Evaluate Potential Hazards

- **Determine the MPE.**

- Determine the Nominal Ocular Hazard Distance (NOHD) for “aided” and “unaided” viewing.
  - NOTE: When the laser beam is directed into a backstop that has sufficient size as to encompass the required buffer areas, the effective NOHD does not extend beyond this backstop.
  - The “NOHD-M” is defined so as to prevent hazardous exposure of personnel potentially using optical viewing aids to view the source of laser.

Outdoor Laser Safety Methodology

Evaluate Potential Hazards

- Determine the Specular Reflection NOHD.
  - Consider:
    - The polarization of the laser.
    - The distance from the laser to the reflector.
    - The size of the reflector.
    - The composition of the reflector material (e.g. generic dirt, foliage (moist broad-leaf?), water, minerals).
    - The surface “flatness” of the material.
- **Determine any required OD for PPE.**

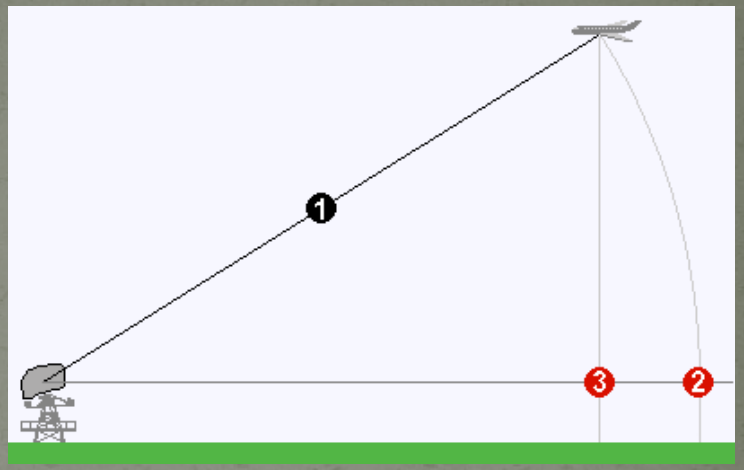
Points to consider

- **ANSI Z136.6 defines "outdoors"** as *a location for a laser where the insertion of a mirror into the output beam path could create a specular reflection that extends indefinitely. However, if the reflected beam thus created does not exceed the MPE anywhere along the beam path, or one of the visual interference levels within the corresponding visual interference zone, then the location need not be considered as outdoors.*

- **FAA Order JO 7400.2H defines "Navigable airspace"** *as airspace at or above the minimum altitudes of flight prescribed by the Code of Federal Regulations, and shall include airspace needed to ensure safety in the takeoff and landing of aircraft. By policy, the term "airspace above minimum altitudes of flight" is interpreted to mean "airspace at or above minimum flight altitudes."*

Subtleties for calculations

- Slant range (1) is the line-of-sight distance between two points which are not at the same level relative to a specific datum. In the absence of altitude information, the location of an aircraft flying at high altitude would be plotted farther (2) than actual (3).



- **EXCEPTIONS**
  - *LFZ, CFZ, SFZ need only be considered for 380-780 nm lasers.*
  - *When control measures (e.g., safety observers) mitigate all hazards or other issues raised by the aeronautical review, irradiance levels may exceed the VILs.*
  - Scientific/research lasers in accordance with 21CFR §1010.5 may be exempt from Title 49.

The solution…

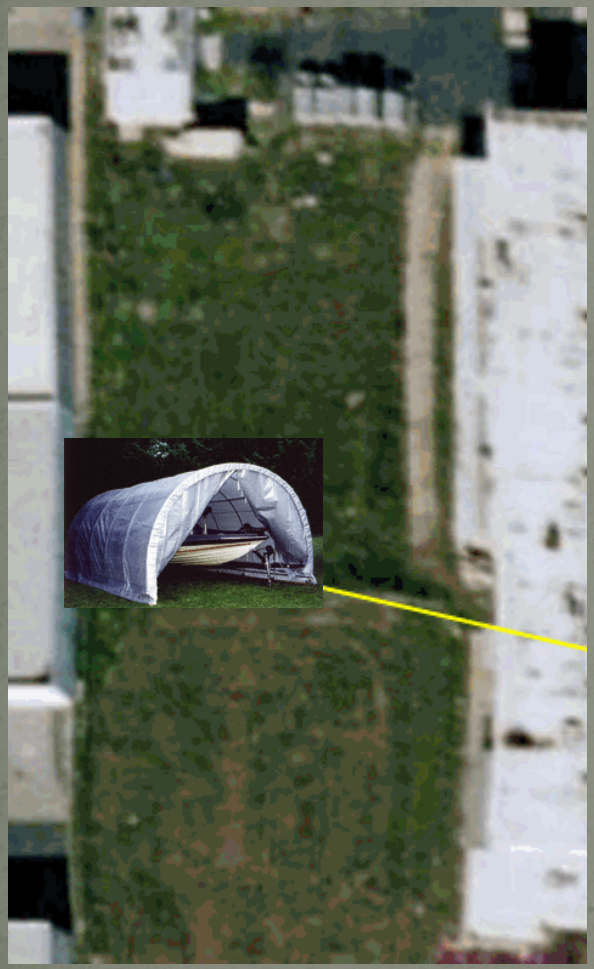
- Develop SOP to consider the three potential hazard areas:
  - Laser controlled area within NHZ:
    - In this sample case it includes an indoor lab.
    - May include temporary outdoor "coverings" (tents, awnings, etc.) which could introduce reflections (e.g. July 5, 2008 laser incident near Moscow, Russia).
  - Airspace potentially affected by laser use.
  - Beam termination point.
- File a completed "*Notice of Proposed Outdoor laser Use*" to with local FAA Regional Office.
- Beam path NOT to be above horizon so LCH need NOT be notified.

Laser Controlled area - Indoor

Low-power visible beam used to align high-power laser

Exit Door Covered with Temporary Restrictive Aperture

Laser Controlled area - Outdoors



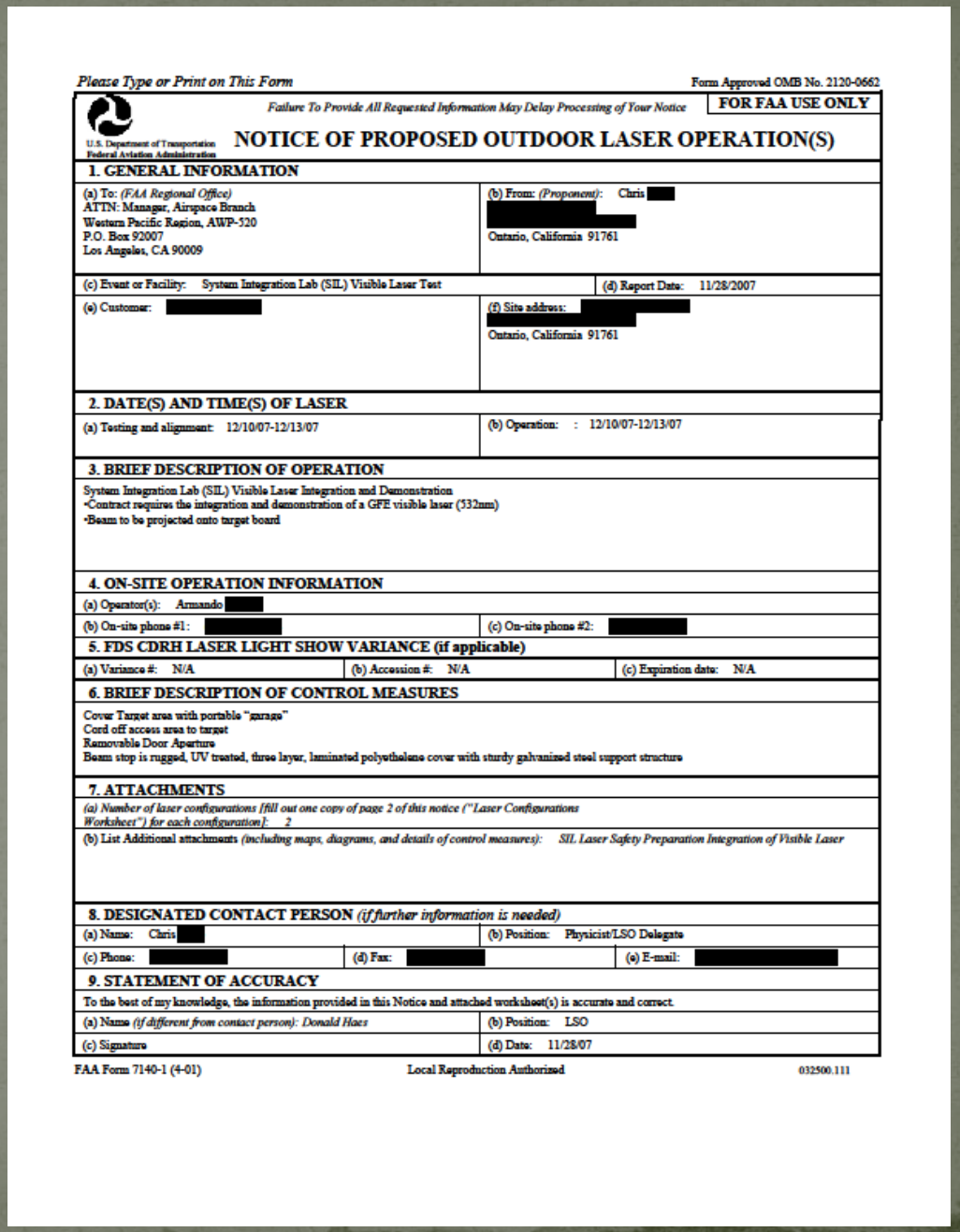
- UV treated Polyethylene cover with sturdy galvanized steel frame construction; Dim: 24’ x 12’ x 10 ½’ .

- Locate additional emergency stop.

- Assign visual observer to monitor the airspace and have adequate means to contact the authorized laser operator for emergency shutdown when aircraft are on course to intercept or cross the flight hazard zone.

FAA Form 7140-1

- Send completed "Notice of Proposed Outdoor laser Use" to local FAA Regional Office.



Please Type or Print on This Form — Form Approved OMB No. 2120-0662

Failure To Provide All Requested Information May Delay Processing of Your Notice — **FOR FAA USE ONLY**

U.S. Department of Transportation
Federal Aviation Administration

NOTICE OF PROPOSED OUTDOOR LASER OPERATION(S)

1. GENERAL INFORMATION

(a) To: *(FAA Regional Office)*
ATTN: Manager, Airspace Branch
Western Pacific Region, AWP-520
P.O. Box 92007
Los Angeles, CA 90009

(b) From: *(Proponent)*: Chris [redacted]
[redacted]
Ontario, California 91761

(c) Event or Facility: System Integration Lab (SIL) Visible Laser Test

(d) Report Date: 11/28/2007

(e) Customer: [redacted]

(f) Site address: [redacted]
Ontario, California 91761

2. DATE(S) AND TIME(S) OF LASER

(a) Testing and alignment: 12/10/07-12/13/07

(b) Operation: : 12/10/07-12/13/07

3. BRIEF DESCRIPTION OF OPERATION

System Integration Lab (SIL) Visible Laser Integration and Demonstration
•Contract requires the integration and demonstration of a GFE visible laser (532nm)
•Beam to be projected onto target board

4. ON-SITE OPERATION INFORMATION

(a) Operator(s): Armando [redacted]

(b) On-site phone #1: [redacted]

(c) On-site phone #2: [redacted]

5. FDS CDRH LASER LIGHT SHOW VARIANCE (if applicable)

(a) Variance #: N/A

(b) Accession #: N/A

(c) Expiration date: N/A

6. BRIEF DESCRIPTION OF CONTROL MEASURES

Cover Target area with portable "garage"
Cord off access area to target
Removable Door Aperture
Beam stop is rugged, UV treated, three layer, laminated polyethelene cover with sturdy galvanized steel support structure

7. ATTACHMENTS

(a) Number of laser configurations [fill out one copy of page 2 of this notice ("Laser Configurations Worksheet") for each configuration]: 2

(b) List Additional attachments *(including maps, diagrams, and details of control measures)*: *SIL Laser Safety Preparation Integration of Visible Laser*

8. DESIGNATED CONTACT PERSON *(if further information is needed)*

(a) Name: Chris [redacted]

(b) Position: Physicist/LSO Delegate

(c) Phone: [redacted]

(d) Fax: [redacted]

(e) E-mail: [redacted]

9. STATEMENT OF ACCURACY

To the best of my knowledge, the information provided in this Notice and attached worksheet(s) is accurate and correct.

(a) Name *(if different from contact person): Donald Haes*

(b) Position: LSO

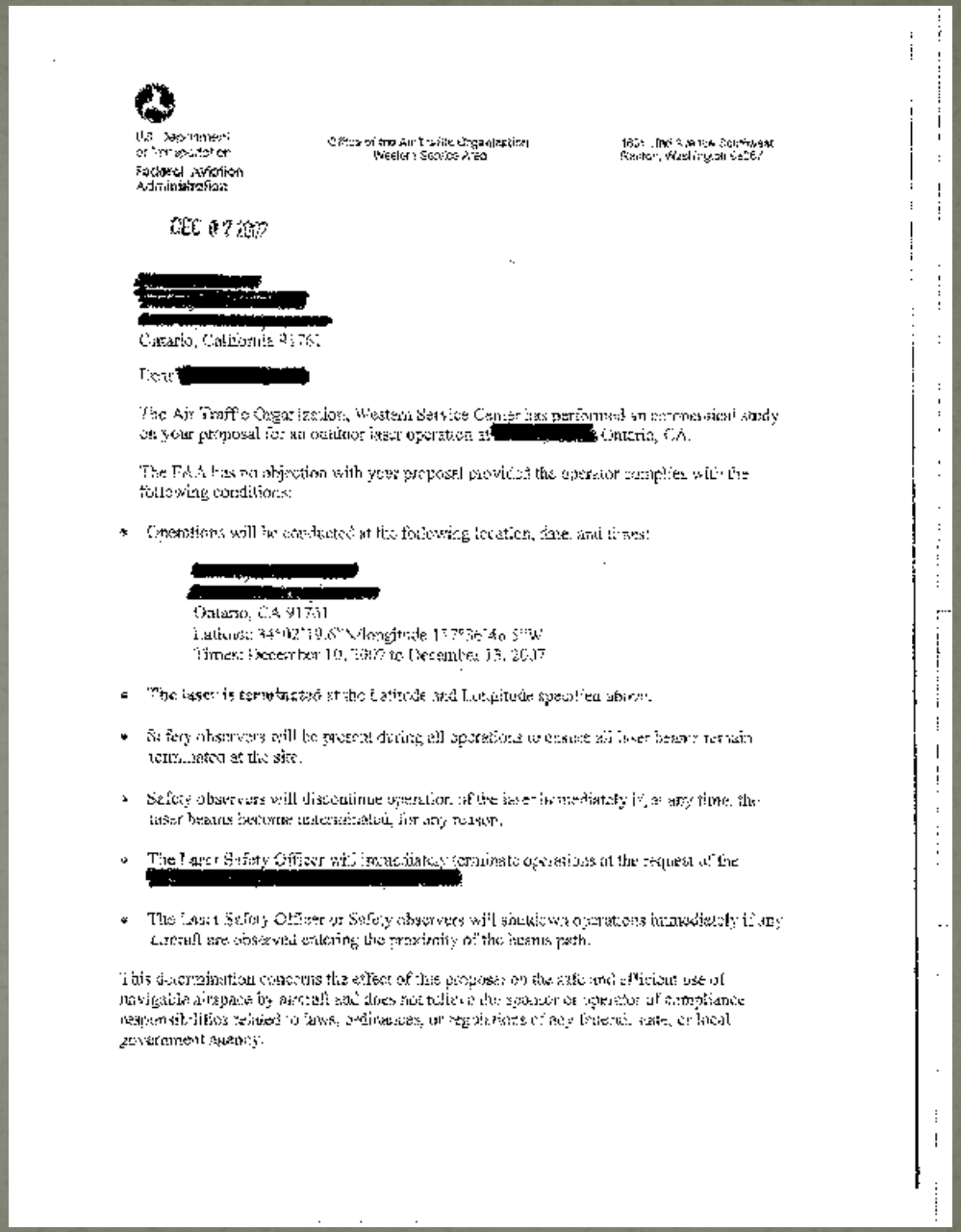
(c) Signature

(d) Date: 11/28/07

FAA Form 7140-1 (4-01) Local Reproduction Authorized 032500.111

FAA Response

- FAA sends a **non-objection letter; NOT "permission"**
- May include FAA-requested additional restrictions or coordination.



U.S. Department of Transportation
Federal Aviation Administration

Office of the Air Traffic Organization
Western Service Area

1601 Lind Avenue Southwest
Renton, Washington 98057

DEC 07 2017

[redacted]
Ontario, California 91761

Dear [redacted]

The Air Traffic Organization, Western Service Center has performed an aeronautical study on your proposal for an outdoor laser operation at [redacted] Ontario, CA.

The FAA has no objection with your proposal provided the operator complies with the following conditions:

- Operations will be conducted at the following location, date, and times:

  [redacted]
  Ontario, CA 91761
  Latitude 34°02'19.6"N/longitude 117°36'46.8"W
  Times: December 10, 2017 to December 13, 2017

- The laser is terminated at the Latitude and Longitude specified above.
- Safety observers will be present during all operations to ensure all laser beams remain terminated at the site.
- Safety observers will discontinue operation of the laser immediately if, at any time, the laser beams become unterminated, for any reason.
- The Laser Safety Officer will immediately terminate operations at the request of the [redacted]
- The Laser Safety Officer or Safety observers will shutdown operations immediately if any aircraft are observed entering the proximity of the beams path.

This determination concerns the effect of this proposal on the safe and efficient use of navigable airspace by aircraft and does not relieve the sponsor or operator of compliance responsibilities related to laws, ordinances, or regulations of any federal, state, or local government agency.

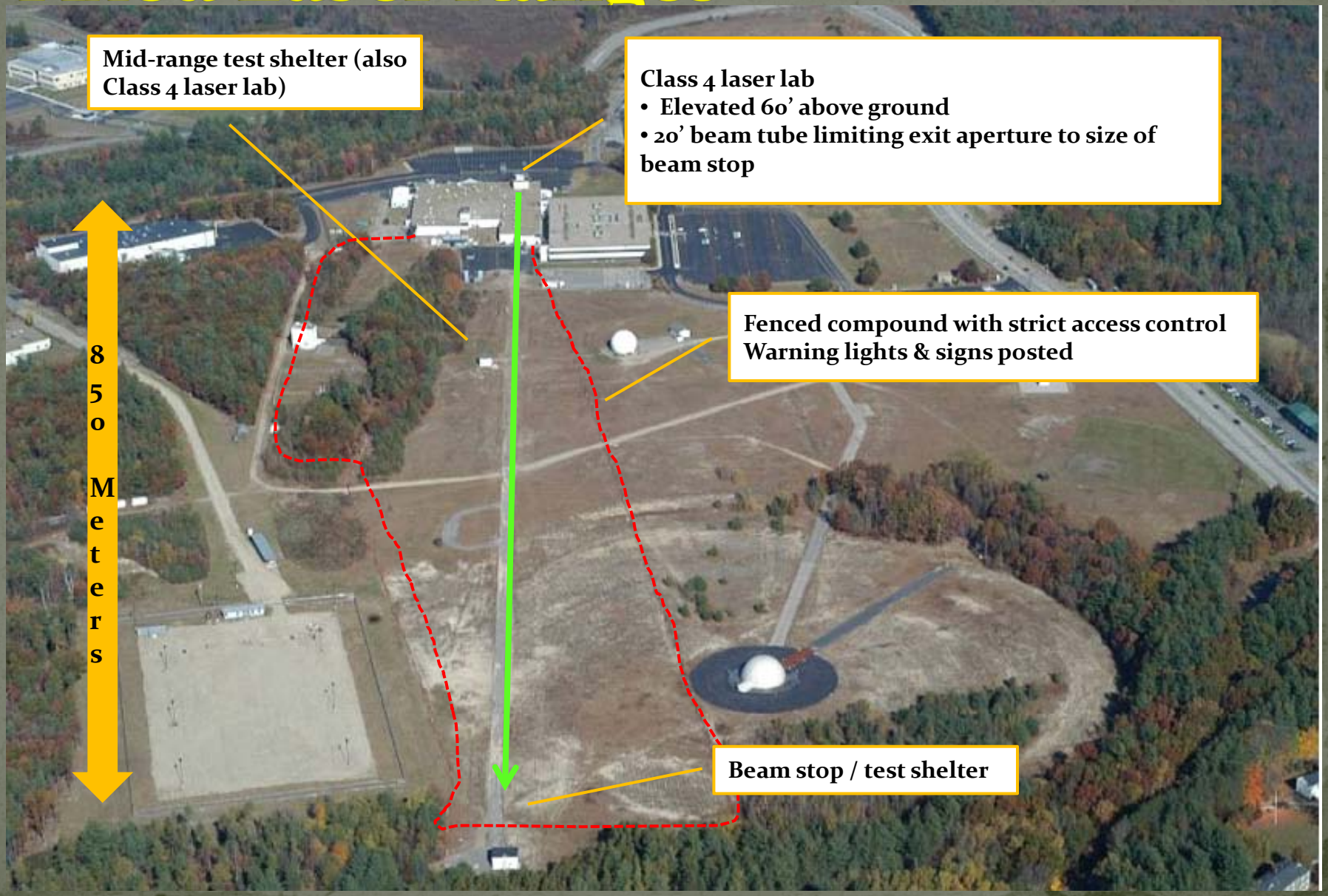
Fixed Laser Ranges

- **DOD Laser System Safety Working Group** established by DODI 6055.15 "DOD Laser Protection Program"; including MIL-HDBK-828B (12/9/09) DOD HANDBOOK - *RANGE LASER SAFETY*.

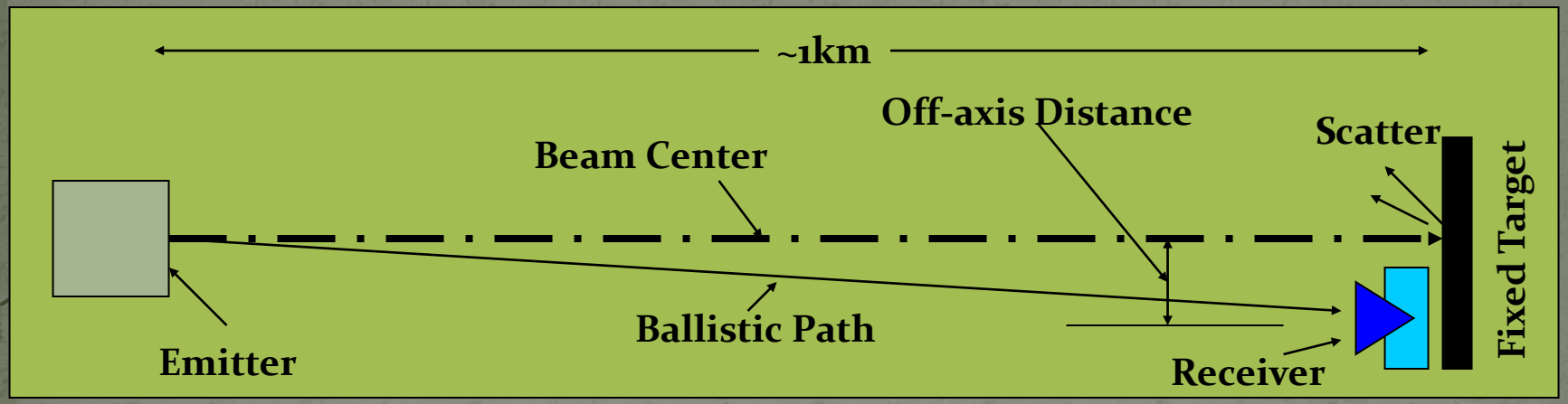
- **Notices to Airmen** (NOTAMs)

- May be posted with "permanent" sign with visual "laser in use" indication.

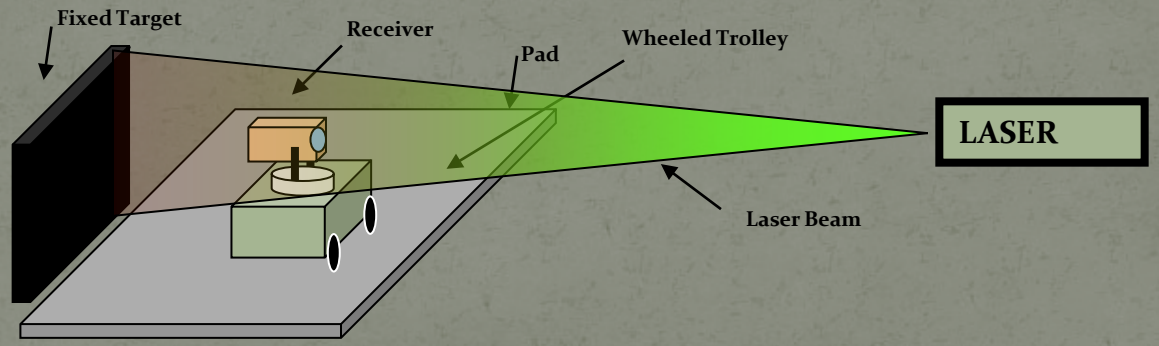
Fixed Laser Ranges



Be *creative…*



"Need to scan target; but that will put beam outside of beamstop".

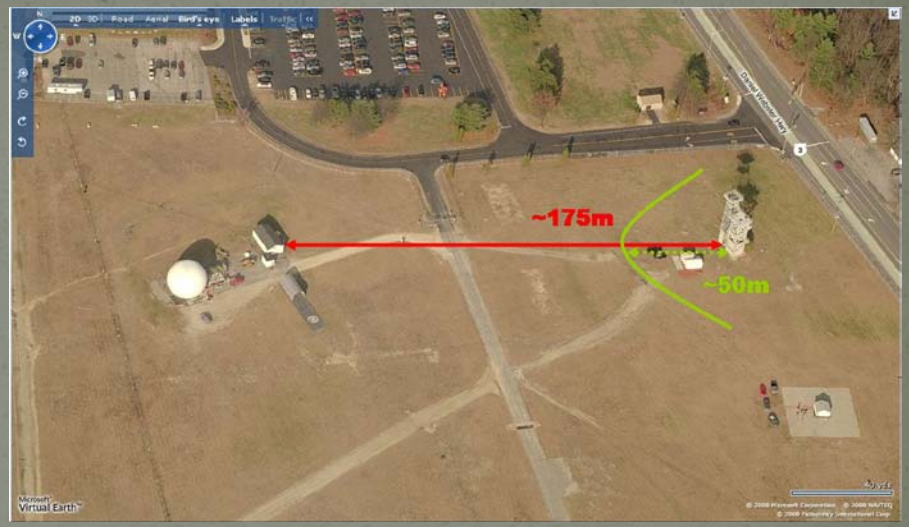


Don't say "no", say "how"

Non-beam hazards

- Personnel hazards include electrical, physical, hazardous materials, confined space, exposure to electromagnetic radiation (RF, UV, IR, VL), and ionizing radiation.

- The LSO *SHOULD* employ safety/human factors, health physics, and/or industrial hygiene personnel to effect the hazard evaluations for special considerations.



Comments? -• • • -• • • • • Questions?